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Diversity of late-Archaean high-K granitoids record the evolution of crustal growth processes

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The late evolution of most Archaean cratons, roughly between 3.0 and 2.5 Ga, is marked by the intrusion of voluminous syn- to post-tectonic potassic granitoids which composition and petrogenesis contrast with the typical Archaean magmatism dominated by sodic TTGs. We based our petrogenetic investigations on granitoids located along a cross section in South Africa, from the northernmost Kaapvaal Craton to the Limpopo Mobile Belt. Three groups of granitoids were recognized on the basis of their specific spatial and temporal relationships:

(1) The younger magmatic event consists in the emplacement of the Bulai pluton (2.60–2.58 Ga) in the Central Zone of the Limpopo Mobile Belt. It belongs to the sanukitoid suite and consists in high-K monzodiorites to granodiorites with relatively high Mg#, Ni–Cr as well as incompatible element contents. On the basis of geochemistry and numerical modeling, we proposed that the source of the mafic end-member (monzodiorite) is an enriched mantle, previously hybridized by a hydrous, felsic magma mostly derived from terrigenous sediments. On the other hand, the more felsic granodiorites either derive from crystallization of these mafic melts coupled with magma mixing or from partial melting of mafic rocks similar in composition to the monzodiorites.

(2) Several granitoid plutons (Mashashane, Moletsi, Matlala, Matok) intruded in the suture zone between the Limpopo Belt and the Kaapvaal Craton at 2.68–2.65 Ga. They are metaluminous, high-K calc-alkaline monzogranites to granodiorites that are generally very widespread in the late-Archaean record. Their trace-element and isotopic characteristics preclude an origin by reworking of TTGs or any other local pre-existing cratonic lithology. Rather, they are likely derived from melting of coexisting intermediate to mafic rocks (calc-alkaline diorites of the Matok pluton, relatively similar in composition to modern arc andesites).

(3) The weakly to strongly peraluminous high-K leucogranites from the Turfloop and Duiwelskloof batholiths (2.78–2.70 Ga) are intrusive in the Kaapvaal Craton granite-greenstone terranes. They are the only granitoids to be only associated with intracrustal differentiation, as their geochemical signature is typical of reworking of older TTGs and/or metasedimentary lithologies.

In summary, by contrast with the relative homogeneity of Archaean TTGs, the granitoid associations recognized in South Africa record a very wide variety of sources for late-Archaean potassic magmatism, ranging from variously enriched mantle to potentially all continental crustal lithologies. Moreover, while moving from the Kaapvaal craton (south) to the Limpopo mobile belt (north) the age of granites decreases correlatively with an increase of the mantle involvement in their source.

Consequently, it seems that the main change at the Archaean-Proterozoic boundary was more complex than believed earlier. Indeed, TTG were not progressively replaced by a single lithology (i.e. sanukitoid), but rather TTG juvenile petrogenetic mechanisms gave way to generalized recycling, which, depending on the source affected by this reworking, would gave rise to a great variety of granitoids. In addition, these granitoid associations resemble those of modern, late- and post-orogenic settings, with juvenile magmatism associated to mantle enrichment above subduction zones as well as intracrustal differentiation, subsequently followed by crust stabilization. This leads us to propose that the Archaean-Proterozoic Transition also represents a period of fundamental change in the geodynamic environment of crustal growth, linked with the initiation of subduction-collision orogenic cycles typical of "modern-style" plate tectonics.

On the other hand, the petrogenetic models developed for differentiated sanukitoids and metaluminous, calc-alkaline monzogranites highlight that potassic granitoids emplaced since the Archaean-Proterozoic transition could have significantly contributed to crustal growth. Indeed, in some cases like for late-Archaean granitoids in South Africa, their petrogenesis could be directly linked to coeval mantle-derived magmatism and does not requires high amounts of pre-existing differentiated crust.